

UNITED STATES DEPARTMENT OF AGRICULTURE

Soil Survey of Randall County, Texas

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and

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Bureau of Chemistry and Soils

In cooperation with the
Texas Agricultural Experiment Station

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SOIL SURVEY

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SOIL SURVEY OF RANDALL COUNTY, TEXAS

By E. H. TEMPLIN, in Charge, and T. C. REITCH, Texas Agricultural Experiment Station

COUNTY SURVEYED

Randall County is in the northwestern part of Texas, in approximately 35° N. latitude and 102° W. longitude (fig. 1). It is one of the central counties of the Texas Panhandle. The northwestern corner is about 100 miles southeast of the northwestern corner of the State. The county includes an area of 920 square miles, or 588,800 acres.

The county lies on the High Plains in the southern part of the Great Plains area. Of the total area, about 82 percent consists of smooth lands of the High Plains, and 18 percent is rough land of the canyons and valleys of Palo Duro Creek and its tributaries.

The High Plains are high, smooth plains. Within Randall County the elevation of these plains ranges from 3,500 to 3,800 feet above sea level. The elevation (15)¹ at Amarillo, Potter County, near the northern edge of Randall County, is 3,676 feet above sea level, and at Canyon City, in the central part, is 3,566 feet. The High Plains have a general easterly or southeasterly slope of about 10 feet to the mile. The surface relief is smooth and constructional, with some alteration due to the formation, through ground settlement, of many enclosed depressions which dot the surface. The depressions range in size from a few square feet to 9 square miles and in depth from a few inches to more than 50 feet. Most of the depressions which are as large as one-half square mile consist of three distinct parts, as follows: (1) A central depressed somewhat round flat occupied by the bed of an intermittent lake, or playa (indicated on the soil map as Randall clay), which constitutes from one-tenth to one-half

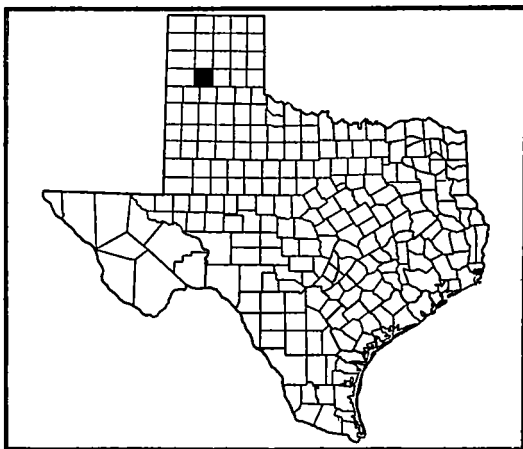


FIGURE 1—Sketch map showing location of Randall County, Tex

¹ Italic numbers in parentheses refer to Literature Cited, p 31.

of the total area of the depression; (2) a surrounding bench which occurs as a concentric ring ranging from one-tenth to one-half mile in width around the central lake bed, with a gentle gradient of about 0.5 percent toward the lake bed, and commonly known as "second bottom" or "bench land"; and (3) an outer surrounding slope which in most places consists of a narrow band with a slope between 1.5 and 4 percent, immediately surrounding the bench land, and surrounding this sharp slope a gentle slope with a gradient ranging from 0.5 to 1.5 percent, which may be as much as a mile long.

According to Gould (16), the High Plains constitute a part of a great outwash debris apron which was spread out eastward from the base of the Rocky Mountains.

The High Plains within Randall County are a small part of a high plateau covering more than 21,000,000 acres of northwestern Texas and extending into eastern New Mexico and western Oklahoma and Kansas. It is surrounded by lower rolling plains—on the west and south by the Pecos River Valley, on the east by the rolling plains of northwestern Texas, and on the north outside the county it is cut through by the valley of Canadian River. The nearly flat plain is bordered by steep bluffs or steep slopes, which constitute an escarpment leading down to the rolling plains several hundred feet lower. The rougher parts of Randall County comprise an interior arm of this rough land extending into the county along canyons. The rough slopes include outcrops of hardened caliche, consisting of nearly pure calcium carbonate, but this does not extend beneath the surface of the plains. The outcrops resembling limestone have probably been formed by the deposition of salts which have been dissolved in ground water that seeped to the surface along the valley walls and evaporated. This caliche outcrop is well developed along the walls of Palo Duro Canyon in the eastern part of the county.

Palo Duro Canyon and its tributary valleys have been formed by erosion, and are cutting back into the High Plains. They are the source of the headwater tributaries of Red River, the main stream a little farther east constituting Prairie Dog Creek, a fork of Red River.

The High Plains of Randall County were originally covered with a dense growth of short grasses, almost exclusively buffalo grass² and blue grama. Palo Duro Canyon and areas of shallow soils on the High Plains were covered with a growth of various plants, consisting largely of black grama, blue grama, needlegrasses, little bluestem, and many other plants. Sandy soils support also some yucca. Within Palo Duro Canyon is a rather heavy growth of cedar (juniper), and cottonwood trees border the courses of the streams. The natural vegetation of this area and its relationship to the various soils is more fully discussed in the Soil Survey of Potter County, Tex. (19), which adjoins Randall County on the north.

Randall County was first settled in 1875. The present population consists of settlers and their descendants who have migrated

² Locally called mesquite grass.

from older sections of the State and from some of the Middle Western States. According to the 1930 census, the total population is 7,071. Canyon, the county seat, has a population of 2,821, and that part of Amarillo that extends into Randall County numbers 1,117 people. Nearly all the rural inhabitants are white.

The county is traversed by lines of the Panhandle & Santa Fe Railway, and all sections have ready access to railway facilities. Additional railway outlets are furnished by the Chicago, Rock Island & Gulf Railway and the Chicago, Burlington & Quincy Railroad, which enter Amarillo on the northern edge of the county. Most of the public roads are well graded and maintained in good condition, and the highway from Canyon to Amarillo is hard surfaced. All sections are served by dirt roads which are excellent during dry weather but are difficult to travel after rains.

Good public schools are located at convenient points. West Texas State Teachers College is located at Canyon. There are no manufacturing industries of importance.

CLIMATE

The climate of Randall County is subhumid, with moderate temperatures. The principal characteristics of the local climate, with special reference to crop production, are (1) a low annual precipitation with irregular seasonal distribution, (2) a very high rate of evaporation, (3) a high average wind velocity, (4) hot summer days followed by cool nights, and (5) moderate winters with some severely cold spells.

The mean annual precipitation during the 41 years of record at Amarillo—1892 to 1932, inclusive—is 21.01 inches. During this time the lowest yearly rainfall was 11.15 inches in 1910, and the highest 39.75 inches in 1923. The total annual precipitation differs widely from year to year. Comparatively, it is one-third more variable than in Illinois. The average distribution of rainfall is very favorable, about 75 percent of the total occurring during the growing season, from April to September, inclusive. However, the actual distribution is very variable and is less favorable than the given figure indicates. Frequently, for several months in succession, no effectual rainfall is received, and crop yields are materially reduced. A year with a comparatively low total rainfall properly distributed may be one of good crop yields, whereas a year with a high total rainfall poorly distributed may be one of low yields. The rainfall may come as light showers which wet the surface only and are quickly lost through evaporation, or it may come as torrential showers, much of which is lost as run-off, especially on the more sloping land. Hence, records of annual rainfall may easily be misleading because of the great importance of distribution.

The average annual relative humidity is low. During the 30 years prior to 1920, the average relative humidity at Amarillo at 7 a.m. was 76 percent and at 7 p.m. was 47 percent (20). The mean seasonal evaporation (April to September, inclusive) from an open water surface during the period 1907 to 1919, inclusive, was 52.08 inches (3).

The average annual wind velocity is high, having been 13 miles an hour during the 31 years preceding 1920 (20). The maximum wind velocity recorded at Amarillo is 84 miles an hour. During the 4-year period, 1907 to 1910 inclusive, an average of 14 days occurred in each year during which the wind attained a velocity greater than 40 miles an hour (1). High winds often cause great damage to crops by quickly evaporating the soil moisture, by covering or cutting off the young plants, or by blowing down the crop when it is almost or entirely mature.

The annual average snowfall at Amarillo during the period of record is 20.7 inches. The snow generally melts within a few days. Hail occasionally causes damage in local areas.

As this section of the country is in the path of storms that sweep southward along the eastern slope of the Rocky Mountains, or that cross these mountains in the State of Colorado and move in a southeasterly direction toward the Gulf of Mexico, it is subject to sudden and great changes in temperature. These changes are most frequent in the winter and are locally termed "northers." Temperatures ranging from 0° to -10° F. occur occasionally during the winter, especially in February. The daily range in temperature is great but, in general, the climate is very healthful and invigorating.

Climatic records have been kept by the Weather Bureau station at Amarillo continuously since 1892 and, in addition, records are available from Canyon, but the latter cover too short a period to be as valuable as those from Amarillo.

The average length of the frost-free season is 201 days. The average date of the latest killing frost is April 13 and of the earliest is October 31. The latest recorded killing frost occurred on May 23 and the earliest on September 22.

Table 1, compiled from the records of the United States Weather Bureau station at Amarillo, gives the normal monthly, seasonal, and annual temperature and precipitation at that station and is representative of climatic conditions in Randall County.

TABLE 1.—Normal monthly, seasonal, and annual temperature and precipitation at Amarillo, Potter County, Tex.

[Elevation, 3,676 feet]

Month	Temperature			Precipitation			
	Mean	Absolute maximum	Absolute minimum	Mean	Total amount for the driest year (1910)	Total amount for the wettest year (1923)	Snow, average depth
	^{°F}	^{°F}	^{°F}	Inches	Inches ⁽¹⁾	Inches	Inches
December.....	37 0	77	-2	0 80		1 11	5 7
January.....	35 3	82	-11	51	0 05	00	3 8
February.....	38 1	84	-16	73	17	1 71	4 7
Winter.....	36 8	84	-16	2 04	22	2 82	14 2
March.....	46 9	96	-2	71	.34	2 97	2 0
April.....	55.8	94	6	1 83	59	3 22	1 1
May.....	64.1	98	26	2 79	2.99	1 70	3
Spring.....	55 6	98	-2	5 33	3 92	7 89	3 4
June.....	72 8	106	38	2 84	66	9 76	0
July.....	76 8	102	51	2 84	3 67	1 85	0
August.....	75 7	102	48	3.08	2.19	1 54	0
Summer.....	75 1	106	38	8 76	6 42	13 15	0
September.....	69 3	101	36	2 30	05	6 42	0
October.....	57 7	94	15	1 66	26	7 34	7
November.....	45 5	85	4	92	28	2 13	2 4
Fall.....	57 5	101	4	4.88	59	15 89	3 1
Year.....	56 3	106	-16	21 01	11 15	39 75	20 7

¹ Trace

AGRICULTURAL HISTORY AND STATISTICS

Randall County and the surrounding territory were first occupied by large ranches about 1875. Prior to this time the country was occupied only periodically by Indians hunting buffaloes. At first most of the county was included within the T Anchor Ranch, the main headquarters of which were located near the present site of the town of Canyon. The early ranches comprised hundreds of square miles each, and the only settlements consisted of the few persons living at the various ranch headquarters or railroad line camps. At first the high plains were utilized for grazing only during the wetter periods when water for livestock was available in the lakes, and the canyon land was relied on for a permanent grass and water supply. Later wells equipped with windmills were drilled on the high plains, and the land was more extensively utilized for grazing.

No crops were grown by the early ranchers, and the native grasses were depended on entirely as livestock feed. In dry seasons, when the pasturage was short, many of the less hardy cattle failed to survive the colder periods of winter, and it was found desirable to feed the weaker cattle during this time. Wild hay, cut chiefly from lake beds or bottom land, and sorgo were first utilized for this purpose, and later, cottonseed cake and the grain and forage of grain sorghums were used.

About 1905, farming as an enterprise separate from ranching began to assume importance. Some of the ranch lands were subdivided into smaller tracts, comprising one or two 640-acre sections. This practice has continued, and a constantly increasing proportion of the land is being devoted to farm crops. During the years 1928, 1929, and 1930, the amount of land in cultivation greatly increased: According to the Federal census, 41.5 percent of the land was classed as crop land in 1930 and only 27 percent in 1925.

According to the 1930 census, there are 843 farms in Randall County, though under that classification are included several land units devoted exclusively to ranching. In 1929, 249,323 acres were devoted to crops, of which 153,397 acres were planted to wheat. As a rule, the proportion of land devoted to crops on the smaller farms is much greater than on the larger farms.

Most of the farms are rather large, more than half of them including from 250 to 1,000 acres each. All land not cultivated is used for pasturing livestock—mainly cattle, either range cattle on the ranches of the larger land units or dairy cattle on dairy farms and general farms. About 45 percent of the farms are operated by tenants.

The total value of land and buildings in 1930 was \$20,681,785, of which the value of land alone amounted to \$18,600,465. The value of field, orchard, and garden crops produced in 1929 was \$3,791,245, of which the value of cereals amounted to \$3,542,631. Hay and forage crops produced were valued at \$221,209 and farm vegetables produced for home use at \$13,244. The total value of domestic animals, including chickens, on farms was \$2,064,076, of which the value of cattle amounted to \$1,688,678, swine \$65,026, sheep and lambs \$80,923, horses and mules \$177,958, and chickens \$50,888. The butter, cream, and whole milk sold in 1929 amounted to \$410,811. The whole milk was valued at \$327,206 and cream sold as butterfat at \$63,712. The poultry raised that year was valued at \$81,840, and the value of chicken eggs produced was \$116,736. Chickens and chicken eggs sold totaled \$106,437.

These figures indicate that, although large-scale production of range cattle and wheat are important and outstanding activities, on the many small farms production is diversified and includes the furnishing of requirements for home use and marketing the surplus not needed on the farms.

The beef cattle are sold as feeders, to be fattened in the corn-producing centers of the Northern States, or to packing houses. Wheat is of excellent quality and in some years commands a premium in the larger markets of the country. Most of the grain sorghums are fed locally to farm livestock. Dairy and poultry products are sold mainly to the local towns on the plains.

The rough broken land is held in large ranches and is utilized for the grazing of range cattle. The land in this county is considered very good for the grazing of steers, but it is said that the winters are sometimes too severe for best results in calf raising. Steers thrive in most winters without much, if any, supplemental feeding, especially in some of the rougher well-grassed areas where protection from cold winds is afforded. Cottonseed cake is the principal feed occasionally given range cattle, though sorghums and other home-grown feedstuffs are sometimes fed.

Most farmers keep a few chickens, several hogs, and a milk cow or two. Several commercial dairies and poultry plants are in the vicinity of Canyon and Amarillo. Grain sorghums and other locally produced feeds are used for feeding the farm animals.

SOILS AND CROPS

Randall County has two main divisions of soils. The first consists of excellent crop land, the soils which are locally known as "High Plains tight land", consisting chiefly of Pullman silty clay loam; the other consists of rough land which is fit for grazing only, as it includes rough broken land and Potter gravelly loam. The occurrence of these two divisions of soils coincides with the physiographic sections of the county—the agricultural soils occurring on the High Plains and the grazing land in the Palo Duro Creek Basin. Agriculture on the High Plains consists primarily of the production of winter wheat, and in Palo Duro Canyon it consists of ranching. This distinction of utilization is becoming more marked, as more of the land on the High Plains is being placed under cultivation each year.

Included within these two main soil divisions are (1) sandy soils, (2) moderately sloping and shallow soils, (3) lake beds, (4) heavy clay benches around lakes, and (5) bottom land; but these subdivisions are of small extent.

Table 2 gives the extent of each soil and the amount and proportion in cultivation.

TABLE 2.—*Approximate area and cultivated acreage of the different soils in Randall County, Tex.*

Soil type	Total area		Area in cultivation	Soil type	Total area		Area in cultivation
	Acres	Acres			Acres	Acres	
Pullman silty clay loam.....	368,512	222,100	60	Potter fine sandy loam.....	5,568	1,000	18
Pullman silty clay loam, dark-colored phase.....	6,208	5,300	85	Potter gravelly loam.....	5,760	0	0
Pullman silty clay loam, bench phase.....	6,528	2,900	44	Zita clay loam.....	16,320	6,800	42
Richfield silty clay loam.....	13,952	8,400	60	Zita fine sandy loam.....	2,560	1,200	47
Richfield clay.....	8,384	2,300	27	Amarillo fine sandy loam.....	12,096	4,600	38
Richfield clay, calcareous phase.....	5,312	1,000	19	Amarillo loam.....	8,384	1,900	23
Randall clay.....	15,872	0	0	Amarillo clay loam.....	12,608	4,900	39
Potter clay loam.....	29,568	5,200	18	Fritch fine sandy loam.....	448	100	22
Potter clay loam, steep phase.....	18,432	0	0	Spur fine sandy loam.....	4,864	2,200	45
				Spur silty clay loam.....	4,096	400	10
				Rough broken land.....	43,328	0	0
				Total.....	588,800	270,300	46

Table 3 gives a comparative classification of the different soils in Randall County and lists certain agricultural characteristics of the land. It must be remembered that this land classification is comparative only to the soils of the county and would not stand with soils in other parts of the United States or even with soils in other parts of Texas.

TABLE 3.—*Agricultural classification of the soils of Randall County, Tex., and their characteristics relating to crop production*

Classification	Drought resistance	Productiveness	Resistance to blowing	Surface relief	Crop adaptation
Heavy excellent agricultural soils					
Pullman silty clay loam.	Good.....	Excellent..	Excellent..	Nearly flat....	Small grains and grain sorghums
Pullman silty clay loam, dark-colored phase	.....do.....	.....do.....	.....do.....	.....do.....	Do
Pullman silty clay loam, bench phase.	.....do.....	.....do.....	.....do.....	.....do.....	Do
Amarillo clay loam	.....do.....	.....do.....	.....do.....	.....do.....	Do
Richfield silty clay loam.	.....do.....	.....do.....	.....do.....	.....do.....	Do.
Richfield clay	.....do.....	.....do.....	.....do.....	.....do.....	Do
Amarillo loam	.....do.....	.....do.....	Good.....	.....do.....	Do
Amarillo fine sandy loam	Excellent..	.....do.....	Fair.....	Undulating....	Grain sorghums
Fritch fine sandy loam	.....do.....	.....do.....	.....do.....	Nearly flat....	Do
Spur silty clay loam	.....do.....	.....do.....	Excellent..	Bottom land	Alfalfa, small grains, grain sorghums, and other crops
Spur fine sandy loam	.....do.....	.....do.....	Fair.....	.....do.....	Alfalfa, grain sorghums, and other crops
Heavy good agricultural soils					
Zita clay loam	Good to fair	Good.....	.....do.....	Flat or sloping	Grain sorghums
Richfield clay, calcareous phase	Good.....	.....do.....	.....do.....	Nearly flat....	Small grains and grain sorghums
Sandy good agricultural soils					
Zita fine sandy loam	.....do.....	.....do.....	.....do.....	.....do.....	Grain sorghums
Heavy fair agricultural soils					
Potter clay loam	Fair.....	Fair.....	.....do.....	Sloping.....	Grain sorghums and pasture
Sandy poor agricultural soils					
Potter fine sandy loam	.....do.....	Poor.....	Poor.....	.....do.....	Pasture and sorgo.
Soils unsuited to crop production used for pasture land only					
Potter clay loam, steep phase	Poor.....	.....do.....	.....do.....	Eroded.....	Pasture
Potter gravelly loam	.....do.....	.....do.....	.....do.....	.....do.....	Do
Randall clay	Fair.....	Fair.....	Fair.....	Lake beds....	Do
Rough broken land	.....do.....	.....do.....	.....do.....	Rough.....	Do

Crop growing in Randall County is confined mainly to Pullman silty clay loam. This soil constitutes 62.6 percent of the total area of the county and 67 percent of the land that is well suited to crop production. It is estimated that 80 percent of the land in cultivation in 1930 was on this soil. The values of the other agricultural soils for crop production do not differ greatly from the value of this soil. Pullman silty clay loam is well suited to the production of winter wheat on a large scale, and therefore this is the dominant crop about which all agricultural operations are centered.

Winter wheat is the most important crop grown. During recent years more than half the land in crops has been devoted to the production of this crop. According to the 1930 census, 153,397 acres, or 70 percent of the land harvested, were devoted to the production of wheat in 1929; in 1924, 33,906 acres, or 21 percent of the crop land, were in wheat; in 1919, 8,028 acres; in 1909, 5,212 acres; and in 1899, none. The census figures report a small acreage devoted to spring wheat. The proportion of the land devoted annually to the production of winter wheat differs rather widely, according to climatic conditions. The great increase in the acreage devoted to this crop since 1924 is largely owing to recent improvements in farm machinery. If sufficient moisture is in the ground in the fall to allow the seed to germinate and to give the young wheat plants a

good start, a large acreage is planted to this crop. Conversely, if the soil is so dry in the fall that wheat prospects are poor, the acreage that year may be reduced, and a larger proportion of the land may be utilized for the production of sorgo, grain sorghums, spring-sown grains, or other crops.

No figures, covering a period of several years, are available for ascertaining the average yield of winter wheat in this county under the present methods of production, but it is between 10 and 15 bushels to the acre. The average yield has been materially increased during the last few years through the adoption of better cultural practices, especially the immediate preparation of the land following harvesting. According to the Federal census, the average yield of wheat was 18 bushels to the acre in 1929, 11.6 bushels in 1924, and 15 bushels in 1919. The year 1929 was one of the best wheat years in the history of this part of the country. The average acre yield of early fall plowed winter wheat at the Amarillo field station of the United States Department of Agriculture on Pullman silty clay loam during the period of years from 1908 to 1914, inclusive, was 8.2 bushels (8). The yield of wheat differs widely with the season and cultural practices. During some seasons individual fields have produced more than 50 bushels to the acre, and yields ranging from 20 to 40 bushels were common throughout whole communities. On the other hand, in some seasons wheat was a total failure throughout most of the county on all except summer-fallowed land. The tillage practices, as well as the good or bad climatic conditions, which the farmer experiences in his attempts to adapt his tillage operations and time of seeding to that particular season, strongly affect the yield.

Grain sorghums are the crops second in importance. Milo and kafir are the two most common grain sorghums, with smaller quantities of hegari, feterita, dorso, and a few others. Milo gives higher yields of grain than any of the others. Dwarf Yellow milo is the most popular variety and constitutes a large proportion of the total grain sorghums grown. The average acre yield of this variety is between 25 and 30 bushels of threshed grain, and the range is from failure to 75 bushels, though years of complete failure are very rare. One field of Dwarf Yellow milo yielded at the rate of 92.9 bushels of threshed grain to the acre at the Amarillo cereal field station in 1915 (21). During the period 1908-16 the average acre yield of this variety on the Amarillo cereal field station was 27.1 bushels of grain (1). The most outstanding characteristic of Dwarf Yellow milo on this soil is its ability to produce good yields of grain, as it withstands dry conditions exceedingly well and also responds well to favorable moisture conditions.

Kafir is the grain sorghum ranking second in importance. Its importance lies in its ability to produce a high yield of grain and also a good yield of forage. It does not produce so much grain as milo, but the forage is much more abundant and more palatable. The average acre yield of the most successful variety, Dawn, at the Amarillo cereal field station (1) on Pullman silty clay loam during the period 1908-16 was 18.8 bushels of threshed grain. During the period 1913-17, the average acre yield of air-dry forage was 2.29

tons (21). The highest acre yield of grain from Dawn kafir, obtained on the station, was 70.7 bushels, and the highest acre yield of air-dry forage was 5.11 tons. The lowest acre yield of forage under good culture was 0.75 ton. This minimum yield illustrates the ability of kafir to produce some forage during the worst years, as 1913 and 1916 were the poorest crop years in the history of the Texas Panhandle.

Other grain sorghums are grown to less extent. Hegari is probably third in importance, and it produces good yields of both grain and forage. Feterita is sometimes grown, and experiments indicate that a somewhat later seeding date—about June 10—is most favorable to this crop. Certain experiments have indicated that feterita may be slightly more resistant to unfavorable moisture conditions than milo, but feterita has never become very popular in this section, indicating that it is probably less well suited. The average acre yield of threshed grain from feterita at the Amarillo cereal field station during the period 1908-16 was only 84 percent of the average acre yield of Dwarf Yellow milo produced under the same conditions.

Sorgo is the crop ranking next in importance on Pullman silty clay loam and similar soils in Randall County. Most farms have a small acreage of this crop grown for forage, and some dairy farms have a rather large acreage. To some extent sorgo is grown as a catch crop when, because of adverse conditions, germination of the grain sorghums has failed and it is too late to replant. Sorgo produces the greatest yield of roughage of any crop grown in this section. The average acre yield of air-dry forage is between 4 and 5 tons. On the Amarillo cereal field station, the Sumac variety produced 10.95 tons of air-dry forage to the acre in 1915, and during a period of 5 years, including 1913 and 1916, which were the most unsatisfactory crop years in the history of the Texas Panhandle, the acre yield of Sumac never dropped below 1½ tons (21).

Corn is grown to only a very small extent on Pullman silty clay loam and similar soils in this county. Corn is not suited to the heavy soils but does fairly well on sandy soils. On Pullman silty clay loam and similar heavy soils, corn produces some fodder nearly every year, but creditable yields of grain are obtained only about once in every 5 years. It is stated locally that on soils of this character corn produces approximately one-half as much fodder and one-third as much grain as kafir, one-fourth as much grain as milo, and one-fourth as much fodder as sorgo. Corn is more susceptible to irregular and insufficient soil moisture and does not have the ability of the sorghums to withstand adverse climatic conditions, especially drought. Corn may be grown very successfully as a garden crop by irrigation from wells. Experiments at the Amarillo cereal field station showed that corn is not well suited to this soil. The average acre yield on fall-plowed land following small grain was 5.4 bushels of grain and 1.2 tons of fodder.

Oats are a crop of comparatively small importance. They are grown to some extent as special feed for poultry and other livestock. Oats produce approximately the same amount of feed as barley or winter wheat and about three-fourths as much as the grain sorghums. The average acre yield of oats at the Amarillo cereal field station

area is 17.6 bushels of grain on land fall-plowed following small grain (5).

Somewhat less barley than oats is grown. Like oats, barley is used by some farmers to a small extent as feed for poultry and other livestock. The culture and adaptation of barley is similar to that of oats, although barley produces slightly more feed.

Sudan grass has proved to be a well-suited forage crop for this section, and it is grown to a moderate extent by the farmers of the county. It is one of the best cultivated pasture crops of the section. Experiments at Goodwell, Okla., on a soil similar to Pullman silty clay loam of Randall County but occurring under somewhat drier climatic conditions (22), showed that Sudan-grass pasture furnished materially more feed than native buffalo-grass pasture. The yield of Sudan grass as forage cut for hay compares favorably with that of sorgo.

Some cotton has been grown on Pullman silty clay loam and similar heavy soils in Randall County, but this crop has proved generally to be less profitable than winter wheat or grain sorghums, and within the last few years practically no cotton has been produced. Cotton is successfully grown on this soil about 50 miles farther south, where the altitude is not so great. The frost-free season in Randall County is generally too short for cotton. In some seasons the early-planted crop may mature, but in other years frosts occur before the crop is ready for harvest.

Broomcorn has been grown on a small acreage of Pullman silty clay loam by a few farmers in the county. Yields and quality were fairly good, but the total production has not become extensive.

With proper care fruit trees of several kinds and garden crops do well on Pullman silty clay loam and other deep soils of the county. Peaches, plums, grapes, and apples are grown in many of the home orchards for the production of fruit for home use. Beans, peas, spinach, turnips, radishes, onions, parsnips, rhubarb, asparagus, tomatoes, lettuce, salsify, beets, and corn are some of the more commonly grown garden crops. Practically all these fruits and garden crops are given some irrigation—generally from the wind-mill-operated wells which supply the farmers' livestock and household water.

Closely associated with Pullman silty clay loam are very small areas of four soils—Pullman silty clay loam, bench phase; Richfield silty clay loam; Richfield clay; and Richfield clay, calcareous phase—which occur mostly as low flats around the intermittent lakes and are locally known as "benches" or "bottoms." These soils are well drained and are seldom, if ever, covered with water. At least two of them—Pullman silty clay loam, bench phase, and Richfield silty clay loam—are fully as productive as typical Pullman silty clay loam, but because these soils are somewhat difficult to distinguish without actually examining the soil and because the clay soils are less productive, or at least harder to work and likely to be infested with weeds, all such bench lands are commonly considered collectively as less productive and less valuable lands than typical Pullman silty clay loam. Farmers, speaking of the land of the High Plains in this section, generally say that the "highland" is better than the "lowland", meaning that Pullman silty clay loam is better

than these soils. Experienced appraisers of farm lands value these soils from one-half to four-fifths as much as Pullman silty clay loam. In general these soils occur in areas forming concentric rings around the central lake bed of Randall clay, though they may not all be present on a particular bench in areas large enough to show on the soil map. Richfield clay, calcareous phase, occurs as the innermost ring surrounded by Richfield silty clay loam, and it, in turn, is surrounded by the outer ring of Pullman silty clay loam, bench phase.

These soils are utilized and cultivated in the same manner as Pullman silty clay loam, though a larger proportion of them is used as pasture land and a smaller proportion as crop land.

In the following pages of this report the soils of Randall County are described in detail, and their agricultural relationships are discussed; their location and distribution are shown on the accompanying soil map; and their acreage and proportionate extent are given in table 4.

TABLE 4.—*Acreage and proportionate extent of the soils mapped in Randall County, Tex.*

Type of soil	Acre	Per- cent	Type of soil	Acre	Per- cent
Pullman silty clay loam.....	368, 512	62 6	Potter gravelly loam.....	5, 760	1 0
Pullman silty clay loam, dark- colored phase.....	6, 208	1 1	Zita clay loam.....	16, 320	2 8
Pullman silty clay loam, bench phase.....	6, 528	1 1	Zita fine sandy loam.....	2, 560	0 4
Richfield silty clay loam.....	13, 952	2 4	Amarillo fine sandy loam.....	12, 096	2 1
Richfield clay.....	8, 384	1 4	Amarillo loam.....	5, 384	1 4
Richfield clay, calcareous phase.....	5, 312	9	Amarillo clay loam.....	12, 608	2 1
Randall clay.....	15, 872	2 7	Fritch fine sandy loam.....	448	0 1
Potter clay loam.....	29, 568	5 0	Spur fine sandy loam.....	4, 864	8
Potter clay loam, steep phase.....	18, 432	3 1	Spur silty clay loam.....	4, 096	7
Potter fine sandy loam.....	5, 668	9	Rough broken land.....	43, 328	7 4
			Total.....	688, 800	

Pullman silty clay loam.—Pullman silty clay loam is known locally as "High Plains tight land." The 4- to 6-inch topsoil is friable silty clay loam which is dark grayish brown when dry and very dark brown when moist. Beneath this layer and extending to a depth of about 24 inches is a layer of dark chocolate-brown clay which is very hard when dry and very plastic when wet. This layer is much heavier in texture, more intractable, and has a more chocolate-brown color than the surface layer. Neither of these layers contains free carbonate of lime, as indicated by lack of effervescence on application of hydrochloric acid, but both layers are well supplied with lime, as they are neutral or only slightly alkaline and are not of acid reaction. Below a depth of about 24 inches the soil material becomes slightly less dark in color and is calcareous, but it is of approximately the same consistence and texture as the soil material overlying it. This third layer extends downward to a depth of approximately 34 inches, where the soil material becomes distinctly shaded with red, ranging in color from reddish yellow to yellowish red. Here, the soil material is somewhat less compact and more easily permeable to water and plant roots. Below the fourth layer, at a depth ranging from 36 to 70 inches and averaging about 48 inches in gently undulating areas, the soil material changes

abruptly to soft chalklike whitish-yellow material, which consists largely of carbonate of lime, with some light-yellow silty clay, commonly known as "soft caliche." This chalky caliche layer, averaging about 12 inches in thickness, merges below with the geological deposit consisting of buff-colored highly calcareous friable clay containing numerous (but less than the caliche layer) soft white carbonate of lime lumps and concretions. This deepest material represents that from which the soil above has been developed through the influence of climate, plants, and other soil-building agencies.

In common parlance, those soil layers overlying the chalky, or soft caliche layer, are spoken of collectively as the soil, and a description of the soil to the effect that it has a certain depth means the depth to the chalky, or caliche, layer.

The top layer of soil, which is the only soil layer commonly disturbed in tillage operations, though rather hard when dry, works readily, when in proper moisture condition, into a very good friable tilth. It may be worked within a rather wide moisture range—from nearly wet to nearly dry. The material occurring between depths of about 5 and 24 inches below the surface is intractable, sticky, and plastic when wet, and very compact and hard when dry. When dry, it breaks into irregular clods, the surfaces of which exhibit a characteristic slick and nodular appearance.

Throughout the second soil layer, plant roots show a tendency to follow the natural crevices, and it is probable that, because of the heavy character of the soil material, some parts of this layer are only imperfectly reached by plant roots. Movement of water throughout this material is slow.

The third soil layer, between depths of about 24 and 34 inches, is similar in consistence to the second layer but does not have the characteristic nodular structure. Beneath a depth of 34 inches the soil material is somewhat less compact. The chalky layer and the underlying geological clay are friable and easily penetrable. Experimental work has indicated that any water which may be stored in or below the soft caliche layer in this soil through summer fallowing, by cropping alternate years, or by other methods of moisture conservation, is generally not capable of being utilized by crops and is lost so far as crop production is concerned.

Pullman silty clay loam is the most extensive soil in Randall County. It comprises 66 percent of the good agricultural land and 70 percent of the total area of the High Plains lying within this county.

The surface relief of Pullman silty clay loam is uniformly smooth and flat or very gently sloping. The slope of the land ranges from 0 to 30 inches in 100 feet, and probably four-fifths of the surface has a slope of less than 1 foot in 100 feet. Depressions occur throughout the area of Pullman silty clay loam, in which the run-off water collects, as no surface drainage system has developed. The greater part of the rainfall, perhaps 90 percent or more where the land is in native sod, (12) is absorbed in the soil as it falls. Drainage is slow but not imperfect, which, considering the climate, is advantageous. Terracing and contour cultivation, to prevent loss of water by run-off, are considered advantageous.

Pullman silty clay loam is an excellent agricultural soil. Most farmers consider it the best soil in the county for the type of farming (predominantly the production of winter wheat) prevalent in this section. The characteristics of this soil, which give to it superior agricultural value, are its comparatively heavy texture, good content of plant nutrients, smooth surface relief, and good water-holding capacity.

The heavy texture renders this soil, with proper tillage, comparatively immune to blowing in the high winds of winter and spring. This immunity is the factor which makes a heavy texture valuable, because where the surface soil is very loose or pulverized during the dry period of winter and early spring, before the young grain has started vigorous growth to offer protection, wheat or other winter-grain fields are often severely injured through soil drifting. In respect to moisture content only, disregarding other factors, the texture of this soil is too heavy to be ideal, as is shown by the fact that the deep sandy soils of the county are better suited to the production of row crops which are not seriously affected by soil blowing. It is probable that the ideal soil texture for the climatic and agricultural conditions of Randall County would be a surface soil of about the same texture as the silty clay loam surface soil of Pullman silty clay loam, but with underlying soil layers considerably lighter in texture and more readily penetrated by water than the heavy clay layers. General agricultural practices and experience indicate that a loam is about as light textured a soil as should be generally utilized for the production of wheat in this section.

Farming experience and agricultural experiments indicate that this soil in its present condition contains all the available plant nutrients which crops are able to utilize with the amount of moisture they normally receive. Water supply, and not fertility, is practically everywhere the limiting factor in crop production on this soil. Farmers state that fields which were broken for cultivation from 20 to 25 years ago and which have been cropped ever since, largely to wheat, apparently yield as well as freshly broken land, as no reduction in yields owing to lessening of fertility has been observable. Chemical analyses (14) indicate that this soil is well supplied with available plant nutrients. Results of experiments have shown that the application of fertilizers to soils such as Pullman silty clay loam, under dry-farming conditions, gives no material increase in yields and is not profitable, but it is considered advantageous to apply such manures and crop residues as may be available.

The soil is not of acid reaction and is well supplied with lime. The application of lime to this soil would probably not be beneficial and possibly might be detrimental.

The smooth surface relief is favorable, in that it prevents much loss of water as run-off, and erosion, such as occurs on more sloping land, is slight. It also allows the laying out of large well-shaped fields ideally suited to the use of power machinery.

Loss of water as run-off constitutes a problem in itself, even on this smooth soil, and should be guarded against. Results of erosion and run-off experiments at the Texas Agricultural Experiment Station, substation no. 7, at Spur, and at the erosion experiment

station of the United States Department of Agriculture at Hays, Kans., are generally applicable to Randall County and to this soil. Results obtained at Spur indicate that large increases in yields of row crops have been obtained through the use of the level terrace and contour cultivation, and it is probable that on much of this soil, terracing and contour cultivation would prove profitable. This soil is rather slowly permeable to soil moisture, owing to the heavy character of the deeper soil layers, and theoretical considerations indicate the desirability of terracing. However, terracing in Randall County up to this time (1930) has not been done sufficiently to demonstrate the advantages.

Erosion on this soil has not thus far been a problem of serious consequence. The land has been in cultivation only a comparatively short time, and some sheet erosion may be taking place. In some places a few gullies have begun to form, most of which are in the natural small drains to lakes or adjacent to road cuts. When considering the possibilities of serious damage to this soil by erosion, the fact that the layer of friable topsoil is very thin and overlies a heavy slowly permeable clay must be taken into account. Consequently, only slight removal of topsoil is a serious matter, and no doubt the soil would be very hard to work, probably more droughty, and considerably less productive, if a few inches of the friable topsoil should be lost.

Pullman silty clay loam is a uniform soil, and although slight variations in the color shades and thicknesses of the various soil layers occur, these differences apparently have no agricultural significance.

Of a total area of 368,512 acres of Pullman silty clay loam in the county, about 222,100 acres,^a or 60 percent, of the total area of the soil were in crop land in 1930. Practically the entire acreage of this soil is in farms other than ranches, and the land not in crops is utilized chiefly as farm pastures and homesteads. Additional areas are continually being placed under cultivation, and none of the soil, after being placed in cultivation, is allowed to revert to native sod pasture.

On the map of Potter County, which lies immediately north of Randall County, a shallow phase of this soil is shown. In the correlation of the soils of Randall County, this phase was combined with typical Randall silty clay loam. It occurs in a large number of widely scattered small areas but is confined practically to slopes along the upper parts of the valleys where they grade off into the smooth upland. The more shallow soil occurs, therefore, in strips along the sides of these valleys and also around the rims of the circular basins which form so striking a feature on the smooth uplands covered with large unbroken areas of Pullman silty clay loam. This included soil is much like typical Pullman silty clay loam, but some, or all, of the soil layers lying above the gray caliche are thinner than the corresponding layers in typical Pullman silty clay loam.

The dark-colored surface layer differs from the corresponding layer in typical Pullman silty clay loam in that it is a little lighter in color

^a This figure and all other figures for acreage in cultivation in 1930 in Randall County are based on actual delineation of the various fields on the soil survey field sheets and measurements.

as well as a little thinner. This soil is slightly less productive than the typical soil, and because of its occurrence on slopes, although the slopes are gentle, it is slightly less favorable for the use of agricultural machinery and is, therefore, not used so extensively for grain crops. Its dominant use is for pasture.

Pullman silty clay loam, dark-colored phase.—Pullman silty clay loam, dark-colored phase, differs from typical Pullman silty clay loam only in that it is somewhat darker colored. Both the surface soil and the underlying heavy clay second soil layer, to a depth of about 12 inches, are nearly black. Soil of this phase has essentially the same value, crop adaptations, and productivity as the typical soil.

Pullman silty clay loam, bench phase.—Pullman silty clay loam, bench phase, is practically identical with the typical soil to a depth of about 30 inches below the surface. Below this depth the soil material grades into brown or brownish-gray clay or sandy clay, containing a few white soft lime carbonate lumps or concretions. Soil of this phase has no distinctly red-tinged layer and no well-defined chalky or caliche layer. This soil occupies the outer parts of the benches which surround the Randall clay areas and some of the flatter parts of the more sloping country in the vicinity of Canyon. It has about the same agricultural value and suitability for crops as typical Pullman silty clay loam.

Richfield silty clay loam.—Richfield silty clay loam differs from Pullman silty clay loam in that the surface soil is darker colored and the lower soil layers are gray. This soil has a 5-inch layer of nearly black friable silty clay loam overlying nearly black compact clay which extends to a depth of about 20 inches. These layers contain no pure lime carbonate. Below this depth the material is calcareous and grades into gray calcareous clay containing a few soft concretions of carbonate of lime at a depth of about 30 inches. This latter material extends to a depth of several feet without change.

This soil is suited to about the same crops and is about equally productive as Pullman silty clay loam. The darker color of the Richfield soil indicates that it contains more organic matter than the Pullman soil.

Richfield clay.—Richfield clay is characterized by a layer, about 18 inches thick, of black noncalcareous clay resting on very dark brown compact calcareous clay which grades below, at a depth of about 30 inches, into gray calcareous clay containing a few soft white concretions of lime carbonate.

Crop yields on this soil approximate those obtained on Pullman silty clay loam, although they average slightly lower. As judged by the farmers, the chief differences between this soil and Pullman silty clay loam are that the Richfield soil is more difficult to work, as more power is required to pull the tillage implements, and the range of moisture content within which the soil may be properly worked is narrower.

A few areas of this soil are gently sloping, and small areas lying adjacent to the lake beds are somewhat lighter in color than typical.

Richfield clay, calcareous phase.—Richfield clay, calcareous phase, differs from Richfield clay in that it is lighter colored and is highly calcareous in all soil layers. It is very crumbly or mealy, which allows the soil to blow, and most of the land is more severely

infested with weeds than the typical soil. The color of the topsoil ranges from bluish gray to dark gray.

This soil has a lower value for crop production than the darker soil and is considered only fair for the production of field crops.

Randall clay.—Randall clay is the soil developed on the old lake beds which occur throughout the High Plains. It consists of heavy compact plastic gray or bluish-gray clay extending downward for several feet with little change other than becoming somewhat lighter colored and containing some rust-brown spots below a depth of about 3 feet. Most of the topsoil is noncalcareous, although as a rule the soil is calcareous below a depth of 24 inches. On drying, the immediate surface soil crumbles to a mealy condition, and cracks form that are several inches wide and several feet deep.

Randall clay in its present condition is not suited to crop production. Most of it is covered with shallow water following rainy periods, and no practical method has been devised to provide artificial drainage for most of the areas, although in places some land could be drained into Palo Duro Canyon or into other drainageways through ditches. Thorough terracing of all the surrounding drainage area would tend to prevent accumulation of water in the lake beds and, possibly, in time, the economic requirements for more land will cause the adoption of such methods.

This soil is intractable, and cultivation would be difficult. Attempts at farming a few areas which are dry most of the time have been generally unsuccessful and have shown that crops do not withstand the adverse moisture conditions, though fair yields have been obtained when rains come at favorable times. Chemical analyses of this soil (14) indicate that it contains a moderate amount of plant nutrients.

This soil constitutes 3.4 percent of the High Plains part of Randall County. It is used for pasture land, and no attempt has been made to cultivate any of the larger areas. A few small cultivated areas, too small to show on the soil map, are farmed with Pullman silty clay loam, but the crops on these areas are commonly unsatisfactory. Most farmers avoid cultivation through the very small areas of this included soil in order not to spread the blueweed, which is common on and near it.

Some of the land is entirely bare of vegetation most of the time, but in places a good growth of native vegetation affords from fair to excellent grazing, and occasionally the "lake grass", or "water grass", which grows on it is cut for hay.

Potter clay loam.—Potter clay loam differs from Pullman silty clay loam in that it is much shallower, is lighter colored, has no red-tinted soil layer, is highly calcareous, and is very friable. This is the shallow "chalky land" of the High Plains. It consists of dark-brown highly calcareous granular and friable clay loam from 10 to 15 inches thick resting on brownish-yellow heavy clay, loam containing a large quantity of soft white lumps or concretions of carbonate of lime. This chalky layer averages about 1 foot thick and rests on the same kind of highly calcareous pinkish-buff clay that underlies Pullman silty clay loam.

Potter clay loam is only fair for crop production. The land is rather strongly sloping, most of it ranging from 2 to 4 percent

gradient, and it is subject to erosion and loss of water by run-off. All areas of this soil in cultivation should be protected from erosion. In cultivated fields the surface soil crumbles to a loose mealy condition so that it blows badly in high winds. In addition, this soil is less productive and the thin layers do not afford a large capacity for the storage of soil moisture. It is not well suited to the production of wheat or other small grains, but fair yields of sorgo and grain sorghums are obtained.

Potter clay loam is recognized by farmers as being less valuable for crops than Pullman silty clay loam. The sloping surface relief and shallow loose soil are features unfavorable to collecting and holding moisture during dry seasons, and the soil is also inherently lacking in sustained productiveness. Farmers report that this soil yields almost as well as Pullman silty clay loam when first placed in cultivation but that yields decline rapidly with continued use. It is good grazing land.

This soil is easily recognized by the character of the soil material, the slope, and the native vegetation which, on the virgin soil, consists of some buffalo grass but with a greater proportion of needle-grasses, whitetop, sage grass, locoweed, and various legumes. The soil is characterized by a cornmeallike structure and by the white limy concretions.

This soil occurs in areas sloping toward the lakes and toward the edge of the High Plains, adjacent to Palo Duro Canyon and tributary valleys. It covers a total area of 46.2 square miles.

Potter clay loam, steep phase.—Areas of Potter clay loam in which the soil is extremely shallow, sloping, and gullied, and is entirely unsuited to crop production, are shown on the soil map as Potter clay loam, steep phase. Here the soil material ranges from only 4 to 10 inches in thickness. This soil is not extensive but occurs in a number of small areas.

Potter fine sandy loam.—Potter fine sandy loam is much like Potter clay loam, except that it has a fine sandy loam topsoil. It ranges from poor to fair for crop production, and where in cultivation is subject to severe erosion. It is of slight extent, and probably most of it is better suited for grazing than for farming.

Potter gravelly loam.—Potter gravelly loam has a layer of dark-brown calcareous loam ranging from 2 to 8 inches in thickness, overlying a bed of hard caliche. Fragments of this rocklike material are scattered over the surface and throughout the thin layer of topsoil.

This soil is so thin and unproductive that it is entirely unsuited to crop growing. It occurs mostly as narrow strips and in small sloping areas in the central and southwestern parts of the county. It is used only for the moderate grazing afforded by the sparse growth of native grasses.

Zita clay loam.—Zita clay loam is darker colored and deeper than Potter clay loam. It is intermediate in character and surface features between Potter clay loam and Pullman silty clay loam. It differs from Pullman silty clay loam in that it is shallower and has no reddish-brown or chocolate-brown soil layers, but it does have the characteristic mealy or granular structure of the Potter soils.

This soil, to a depth of about 18 inches, is very dark brown, or almost black friable clay loam. It is underlain by brown calcareous

clay loam which, at a depth ranging from 24 to 36 inches, rests on a layer of soft caliche. In most places the upper soil layer contains no free lime to a depth of about 10 inches, but below this depth the material is highly calcareous. The soil material in all layers above the soft caliche is clustered into small, somewhat rounded, corn-meallike granules giving the material a loose friable consistence, which allows the soil to drift in heavy winds; hence, it is not so well suited to growing small grains as Pullman silty clay loam. However, it produces excellent yields of other field crops. It is somewhat lower in agricultural value than Pullman silty clay loam but ranks higher than Potter clay loam.

This soil is not extensive. The larger areas occur in the southwestern part of the county and in the vicinity of Canyon.

Zita fine sandy loam.—Zita fine sandy loam is somewhat similar to Amarillo fine sandy loam but is shallower and not so distinctly red. The soil ranges from 30 to 36 inches in thickness over soft caliche and is calcareous, except in the topsoil. This soil consists of dark-brown friable granular fine sandy loam to a depth of about 18 inches. It overlies yellowish-brown calcareous loam, which rests on the soft caliche.

This is a good agricultural soil.

Amarillo fine sandy loam.—Amarillo fine sandy loam is locally known as "red sandy land." The chief differences between this soil and Pullman silty clay loam are that the Amarillo soil is more sandy, more red, and more easily permeable in all soil layers. It occurs in small irregular areas that have more sloping surface relief than Pullman silty clay loam.

Amarillo fine sandy loam consists of dark reddish-brown granular fine sandy loam about 10 inches thick overlying reddish-brown friable granular loam which grades below, at a depth of about 30 inches, into yellowish-red calcareous loam. At a depth ranging from 3 to 7 feet, this material grades into chalky, almost white, soft caliche.

Considered agriculturally, the differences between this soil and Pullman silty clay loam are that the Amarillo soil is less well suited to the production of small grains than the Pullman soil, on account of its tendency to blow; it is more drought resistant and more easily worked on account of the coarser texture; and it is fully as good or better for sorghums and other cultivated crops, such as corn, vegetables, and fruits. On the other hand, it is somewhat less suited than the Pullman soil to the extensive use of power machinery.

Most of this soil occurs on the moderately sloping land near Canyon.

Amarillo loam.—Amarillo loam is intermediate in texture between Pullman silty clay loam and Amarillo fine sandy loam. It is of slight extent but occurs in a number of scattered small areas. It is a good soil for the production of grain sorghums and other cultivated crops.

Amarillo clay loam.—Amarillo clay loam differs from Pullman silty clay loam in being more red; commonly has slightly more slope than the average for Pullman silty clay loam; and the fourth, or red, soil layer, which immediately overlies the caliche, is generally somewhat lighter textured and less compact than the corresponding

layer in the Pullman soil. In places the texture of the topsoil layer is loam. This soil has about the same agricultural value and suitability for crops as Pullman silty clay loam.

Fritch fine sandy loam.—Fritch fine sandy loam is darker than Amarillo fine sandy loam. It is underlain by heavy clay at a depth ranging from 1 to 2 feet. This soil consists of dark-brown or very dark brown friable fine sandy loam ranging from 12 to 20 inches in thickness. It contains no free lime carbonates. The topsoil is underlain by black, dark-brown, or bluish-gray clay. This soil might be considered as Randall clay which has been covered with a fine sandy loam surface layer. It occupies slight depressions within areas of Amarillo fine sandy loam but is never covered with water.

This is an excellent soil, and it has approximately the same agricultural value and crop relationships as Amarillo fine sandy loam.

Spur fine sandy loam and Spur silty clay loam.—West of the town of Canyon, along Palo Duro and Tierra Blanca Creeks, are alluvial belts ranging from one-fourth to 1 mile in width, which are sufficiently large to allow satisfactory cultivation. Here the soils are dark brown and calcareous, and they are represented by two soil types—Spur fine sandy loam and Spur silty clay loam. A few areas of loam, loamy fine sand, and clay are included, but they are too small to indicate separately on the map.

Spur fine sandy loam and Spur silty clay loam have approximately the same general characteristics, differing only in the texture of the surface soil, and they are about equal in agricultural value.

These soils are well drained and are not subject to frequent overflow. The water table lies at a depth ranging from 5 to 20 feet below the surface, generally within beds of sand or gravel. Water-soluble salts do not occur in these soils; at least, in most places they are not present in sufficient quantities to cause injury to plants. As underdrainage is moderately free, probably no trouble from alkali accumulation will occur. Water in sufficient quantity for irrigation is available from shallow wells and, to some extent, from the creeks, but irrigation has not been extensively practiced.

In the vicinity of Canyon, a large proportion of these two soils, which are excellent agricultural soils, is utilized for the production of alfalfa. Farmers report that well-established stands of alfalfa grow for a period ranging from 15 to 30 years, and acre yields range from 1 to 3 tons a season without irrigation. Yields of the grain sorghums and sorgo average well above those on Pullman silty clay loam. However, little of these soils occurring 5 miles west of Canyon is in cultivation.

Rough broken land.—Rough broken land includes those areas where the sharp relief is the dominating characteristic. Areas which are too rough for cultivation are shown as rough broken land, regardless of the character of the soil material. Within Randall County, Palo Duro Canyon and its tributary canyons constitute the areas designated as rough broken land. Included within these areas are small areas of smooth soils too small to map separately, which provide very good grazing land for livestock.

For grazing purposes, rough broken land is generally valued as highly as the smoother lands of the High Plains. Water for livestock is available in most places from small springs and seeps.

AGRICULTURAL METHODS AND MANAGEMENT

Winter wheat is the dominant crop in Randall County, and the agricultural practices in use are primarily concerned with its production. Cultural practices are largely those which have proved suited to Pullman silty clay loam, as this valuable wheat soil occurs in large areas.

Cultural practices in the production of winter wheat are here concerned primarily with the conservation of soil moisture, which is largely facilitated by preventing weed growth. Because wheat is grown year after year on the same land, the crop season begins immediately following harvest. The common practice, which according to present knowledge seems best, is to follow the combine harvester immediately with tillage implements which destroy weeds and thus prevent loss of soil moisture. The one-way plow is commonly employed for this purpose. Plowing to a depth of 2 or 3 inches with a one-way plow is considered just as good preparation for the following wheat crop as plowing deeper with a disk or moldboard plow, the only disadvantage being that the shallow-plowed land may possibly blow somewhat more than the deeper plowed land, but this possibility has not been demonstrated. Some farmers begin tillage operations at the time they start harvesting, running both combine and one-way plow in the same field at the same time, so that the first plowing is completed within a very short time after harvesting. If the land is plowed immediately following harvesting, sufficient moisture generally remains in the soil to allow tillage, whereas, if plowing be delayed for a week or more, the soil becomes too hard to plow. Following the first tillage, the frequency and times of further cultivation depend on the rains and the accompanying growth of volunteer wheat and weeds. In general, it is necessary to rework the land once or twice before seeding, and these operations are accomplished in the same manner as the first plowing (with the one-way plow). Good farmers attempt to keep the land free of weeds and volunteer wheat with as few cultivations as possible, not only to spare labor and expense but also to avoid too excessive pulverization of the soil, which results in excessive blowing the following spring.

Winter wheat is seeded between September 10 and the last of December, but October 15 is considered about the best date. Date of seeding tests at the Amarillo field station gave very variable results, but approximately equal yields are obtained from seeding about October 1, October 15, November 1, and November 15. This test extended over too short a time to be considered conclusive, but it is in line with the farmers' experience that during some seasons one date of seeding is best, whereas during other seasons different dates are more successful. Wheat is seeded at a rate ranging from 2 to 4 pecks to the acre, with different types of drills. A few furrow drills are being used experimentally in this section, but as yet their superiority is not assured. Following seeding no further work is generally necessary on the wheat until harvest. A few farmers practice spring harrowing of winter wheat, but, as a rule, this is not considered beneficial. An additional operation, which is practiced only during seasons when soil blowing is especially bad, is that of plowing furrows in the wheat field at right angles to the prevailing wind

direction, in order to roughen the surface and check soil drifting. When the wheat makes a too heavy fall growth, it is sometimes grazed back.

Wheat is harvested almost exclusively with combines, although these machines have come into use only within the last few years. Tractors and tractor implements are used extensively in the production of wheat. Farmers in this section who grow only wheat use tractors exclusively—no horses or mules—but comparatively few of the farmers grow wheat exclusively. Most of them keep some livestock, produce some row crops, and therefore keep some horses. In addition to work animals, nearly every farmer has a tractor and performs most operations in connection with wheat growing with the tractor. Little or no difficulty is experienced with poor footing or packing of the soil with tractors. In most places, whenever the soil is too wet to allow the use of the tractor, it is also too wet for plowing or other tillage. A standard 15- to 30-horsepower tractor, pulling a one-way plow cutting from 2 to 4 inches deep, covers from 8 to $3\frac{1}{2}$ acres an hour under normal conditions on Pullman silty clay loam. The same tractor, pulling a disk plow cutting from 3 to 5 inches deep, which is used for sod breaking and occasionally for deeper cultivation, covers from $1\frac{1}{4}$ to $1\frac{3}{4}$ acres an hour under like conditions. Other implements commonly used in the production of wheat are a 20-disk 8-inch drill, seeding a width of 13 feet, and a 16-foot combine that can be pulled with a somewhat smaller tractor at a speed ranging from 3 to 4 miles an hour.

Cultural experiments on winter wheat conducted at the Amarillo field station (8) during the comparatively poor wheat years between 1908 and 1914 showed (using early fall plowing as a standard of comparison) an acre decrease of 1 bushel, or 12 percent, with late fall plowing; a decrease of 1.3 bushels, or 17 percent, with disking on corn ground; a decrease of 1.8 bushels, or 22 percent, with listing; a decrease of 1.3 bushels, or 17 percent, with subsoiling; a decrease of 4.4 bushels, or 54 percent, with green manuring; and a decrease of 2.8 bushels, or 35 percent, with fallowing and cropping in alternate years. The listing and subsoiling were performed at the same time as the early fall plowing. The listing tended to increase yields during the better years and to decrease them during the poorer years. Subsoiling, an expensive process, actually decreased the yields. Disking was practiced on land which was in corn the previous year, whereas all other cultural treatments were on land in wheat the previous year, and the difference in yield was probably owing largely to the different crop grown the preceding year.

The yield of winter wheat is, in general, somewhat greater when following wheat or other crops which are harvested in the early summer than when following grain sorghums or other crops which are harvested late and do not allow early summer preparation of the land. This is probably owing to the greater opportunity for storage of moisture during the fallow period following early harvest and preceding reseeding the same year. Cultural experiments on winter wheat at Hays, Kans. (2), under more humid conditions, indicate that some of the increase in yield may possibly be owing to the liberation of available nitrogen during the fallow period.

Most of the wheat grown in Randall County is Turkey, although Kanred, Blackhull, and Kharkof are occasionally grown. Variety tests of winter wheat conducted by the Amarillo cereal field station on Pullman silty clay loam (10) during the period 1906-19 showed Kanred, two strains of Turkey (C.I. 2223 and C.I. 1558), Theiss, and Beloglina as the high-yielding varieties, in the order named, of those tested.

The method of preparation of the land for grain sorghums is somewhat less standardized than that for winter wheat. On Pullman silty clay loam and similar soils of the High Plains the grain sorghums generally follow winter wheat. Commonly, the land is plowed with the one-way plow immediately following wheat harvest. It is listed in the fall, splitting the middles with the planter at the time of seeding, so that the seed is placed in the new beds and the old middles. As a rule less care is used in preventing weed growth in cultural operations preceding the growing of sorghums than when preparing land for wheat. This is owing largely to the desirability of keeping the soil unpulverized, in which condition it is less susceptible to blowing. Conserving soil moisture in the fall is not so imperative for grain sorghums as for wheat, as they are planted in the spring after rains. Although sometimes allowed, it is not considered good practice to leave grain-stubble land undisturbed until spring, as preparation of the soil for grain sorghums at that time causes the loss of considerable moisture. Grain sorghums are often planted on wheatland where the fall moisture conditions have been unsatisfactory for wheat and are sometimes used as catch crops when the wheat has failed to make a good growth during the winter. Experiments at the Amarillo cereal field station (9) indicated that on Pullman silty clay loam the yields of milo and kafir ranged from 10 to 15 percent greater following small grains than when the preceding crop was a grain sorghum. This indicates that the moisture stored in the late summer following the wheat crop, with also the possibility of an increase in the availability of plant nutrients during the period of fallow, is of material benefit to a following grain-sorghum crop. Spring plowing gave yields approximately 90 percent as large as those obtained with fall plowing, and listing gave somewhat lower yields than plowing. Summer tilling or fallowing, and cropping in alternate years, did not prove so profitable as growing a crop every year. Results of experiments also indicated that neither green manuring nor subsoiling were profitable.

Date-of-seeding experiments at the Amarillo cereal field station indicated that the normal time of seeding, between May 20 and May 25, was best for Dwarf Yellow milo. The yields were influenced to such an extent by seasonal conditions that no arbitrary date of planting could be recommended. Kafir is planted somewhat earlier than milo, and experiments indicate that between May 10 and May 15 is about the best time (18).

Preparation of the land for sorgo is the same as that for the grain sorghums, although sorgo may be safely planted much later than the grain sorghums.

The spring grains—spring wheat, oats, and barley—are sown in late winter after a preparation of the soil similar to that for winter wheat.

The culture of winter wheat, grain sorghums, sorgo, corn, spring wheat, oats, barley, and other crops was studied at the Amarillo cereal field station. The experiments were conducted on Pullman silty clay loam and are applicable to the soils of Randall County. The results of the experiments are reported in a series of bulletins of the United States Department of Agriculture (1, 4, 5, 6, 7, 8, 9, 18), to which the reader is referred for further information.

Where grown on the bottom lands, alfalfa is sown on a firm seed bed in the spring or fall. After a satisfactory stand is made, the field is generally left in alfalfa for a period ranging from 10 to 20 years. The reader is referred to Bulletin 137 of the Texas Agricultural Experiment Station (11) for recommendations on the culture of alfalfa.

Recommendations for improvement in agricultural methods and management in Randall County consist essentially of keeping the land free of weeds and in good tilth with as little expense as possible. With continued farming in this comparatively new agricultural section, more appropriate and efficient methods of farm practice doubtless will be developed, that will tend to offset the vagaries of the climate, which sometimes cause inadequate soil moisture. Terracing the land and contour cultivation to conserve soil moisture and to prevent soil erosion are valuable aids in increasing crop yields and in maintaining productiveness of the soils of the plains region. Thus far the use of commercial fertilizers in dry farming on Pullman silty clay loam has not proved profitable (13).

SOILS AND THEIR INTERPRETATION

Randall County, Tex., lies within the southern Great Plains area, wherein the normal, well-developed soils are underlain by a zone of carbonate concentration consisting chiefly of calcium carbonate. It also lies within that part of the soil region, wherein the normal soils are the darkest colored, the highest in content of organic matter, and the thickest above the zone of carbonate concentration of any normal soils occurring in the same latitude or under the same conditions of temperature. Accordingly, the county lies within the belt of southern chernozems, or black-earth soils.

The soils of this county are comparatively high in content of organic matter. They have developed under a short-grass vegetation which originally consisted of an almost pure stand of buffalo grass (*Bulbilis dactyloides*) and blue grama (*Bouteloua gracilis*).

The parent materials of all the soils are the High Plains deposits, or fresh-water deposits, classified as undifferentiated Cenozoic in age (17), which were laid down as a great debris apron at the eastern base of the Rocky Mountains. The deposit is several hundred feet thick, unconsolidated, and heterogeneous in composition, ranging from clays to beds of water-worn gravel. In Randall County, the topmost layer of this deposit, which has been exposed to soil-building forces, is uniform in character and consists of pinkish-buff friable highly calcareous clay containing numerous spots and accretions of white soft carbonate of lime. In the vicinity of Canyon the lower parts of the High Plains deposit, which are more sandy, have been exposed on moderately sloping areas, and sandy soils have developed. Geological deposits belonging to the

Triassic and Permian systems are also exposed in the county, in Palo Duro Canyon, but not in areas sufficiently smooth to have allowed normal soil development.

The Pullman soils are by far the most extensive soils in the county. They are characteristically of claypan structure. The typical profile of a Pullman soil consists essentially of a dark chocolate-brown surface layer overlying a reddish-yellow layer resting on friable clay containing accumulated soft calcium carbonate. Organic matter is present in comparatively large quantities to a depth of about 20 inches below the surface. The surface layers are neutral or slightly alkaline in reaction. Free carbonates have been completely removed from the upper layers to a depth of about 2 feet by leaching and are concentrated at a lower depth within the solum and immediately above the parent material. The normal zone of greatest concentration of carbonates (the caliche layer) ranges from a depth of 3½ to 6 feet in Pullman silty clay loam. The caliche zone is not indurated. The surface layer of soil, which may range from 3 to 18 inches in thickness, is somewhat lighter in texture than the material beneath. The immediate topsoil is friable, but the material of the layer just beneath is very compact and separates on drying into hard small clods with a slick surface, from which protrude small somewhat rounded lumps.

Following is a description of a profile of typical Pullman silty clay loam as observed in a cut of the Santa Fe Railway about 5 miles north of Canyon. The soil here is under undisturbed native buffalo grass sod. The land surface is smooth and has a slope of less than 1 percent.

0 to 5 inches, silty clay loam which is very dark brown when wet and grayish brown when dry. The material shows no effervescence with hydrochloric acid and is neutral or slightly alkaline in reaction. It is slightly hard when dry, friable when moist, and slightly plastic when wet. The upper 2 inches have a poorly defined platy arrangement of soil particles. When moist this layer crumbles to a mass of fine particles which resemble fine bread crumbs. When dry it breaks to clods of irregular size and form. This layer is sharply defined at the line of contact with the layer beneath.

5 to 24 inches, heavy clay which is very dark chocolate brown when wet and dark chocolate brown when dry. The material on the broken surfaces along cleavage lines is slightly darker than the material within. The material shows no effervescence with hydrochloric acid. It is very hard when dry, very plastic when wet, and very compact when moist. This layer breaks into clods which have slick-appearing and bumpy or nodular surfaces, the clod surfaces being composed of parts of the surfaces of many smaller soil structure units or granules which are somewhat round, about one-eighth inch in diameter, and firmly bound together to form the soil clod. These granules may be picked out separately, but at no moisture condition will the material in this layer readily fall into the separate granules. Plant roots follow the natural soil cracks and structural lines. Following frosts or rains, the material in exposed parts of this layer crumbles to a fine crumb-like condition.

24 to 36 inches, brown calcareous clay containing a few soft calcium carbonate concretions and white calcareous films coating the natural soil crevices in the lower part. The material breaks into cube-like particles about one-half inch in diameter, with flat and slick-appearing surfaces which are coated with a thin film of dark-brown or very dark brown material, and the insides are brown or dark brown. The material in this layer is very hard when dry, very compact when moist, and very plastic when wet. The change from the layer above is gradual. Plant roots follow cracks.

- 36 to 48 inches, dull reddish-yellow noneffervescing clay containing a few soft white aggregates of calcium carbonate about one-fourth inch in diameter. The upper part of the material breaks into cubelike particles the same as in the layer above. This layer is slightly less compact than the overlying layer. A network of fine white calcareous threads occurs throughout the lower part of this layer which rests abruptly on the layer beneath.
- 48 to 60 inches, the caliche layer which consists of friable calcareous buff-colored clay containing 50 percent or more of white soft lumps of calcium carbonate.
- 60 to 80 inches +, the parent material which consists of buff or pinkish-buff calcareous friable clay containing numerous (though less than the overlying caliche layer) soft lumps of calcium carbonate. This material is porous and thoroughly permeated with a network of fine tubes.

Aside from very slight variations in the color shades and the thicknesses of the different layers, Pullman silty clay loam in Randall County is uniform. Within a range of slope of less than about 2½ percent the soil on the High Plains part of the county is Pullman silty clay loam. The difference in color between the land with less than one-half percent slope and that with 2 percent slope is slight, the more sloping soil being slightly lighter in color but generally not more red. Most of the flatter areas are not sufficiently dark to have been separated as a phase of typical Pullman silty clay loam.

A variation occurring 2¼ miles southwest of Jowell School in the southwestern part of the county shows the following profile. This included soil occupies a gentle easterly slope of about 2 percent gradient. The same type of variation, with less degree of development, occurs 3 miles northeast of Rusk School in the southeastern part of the county.

- 0 to 4 inches, dark-brown, with a distinct red cast, noncalcareous silty clay loam.
- 4 to 10 inches, dark reddish-brown noncalcareous clay with a structure like that of the second layer of the described profile of typical Pullman silty clay loam.
- 10 to 20 inches, dark reddish-brown noncalcareous clay which breaks out as cubelike blocks about one-half inch in diameter with flat slick faces, though in the upper part the faces are somewhat nodular or bumpy.
- 20 to 28 inches, calcareous dark-brown clay containing a few semihard concretions of carbonate of lime. The material breaks out as cubelike blocks about one-half inch in diameter, which are coated with a film of dark-colored material.
- 28 to 34 inches, a gradational zone.
- 34 to 42 inches, brown calcareous clay with distinct coatings of iron along all breakage lines. The material breaks out as small clods with rounded corners.
- 42 to 52 inches, same material as in the layer above, except that the basic color is yellowish red instead of brown. Lime films and concretions are more abundant than in the overlying layer.
- 52 to 60 inches +, the caliche layer which is the same as that in typical Pullman silty clay loam.

Another variation of slight extent, which occurs in all the extensive cuts of Pullman silty clay loam observed in the county, shows the following profile as observed in a cut along the Santa Fe Railway 3 miles south of Amarillo:

- 0 to 5 inches, dark grayish-brown (when dry) noncalcareous silty clay loam, as in the typical soil.
- 5 to 24 inches, dark chocolate-brown (when dry) compact noncalcareous clay. The material in this layer is identical with that in the corresponding layer in the typical soil.

- 24 to 60 inches, dark-brown calcareous clay which breaks out as fine irregular and somewhat angular clods ranging from one-eighth to one-half inch in diameter. Along natural cleavage lines the material is coated with a thin film of white calcareous salts. This layer contains a few small hard calcium carbonate concretions.
- 60 to 70 inches, grayish-brown when moist, gray when dry, clay containing numerous rather hard lumps or concretions which are noneffervescing and are white on the outside and yellowish brown or black on the inside. The fine-earth material in this layer is not calcareous, although a few white calcareous films occur along the soil breakage lines in the upper part of the layer. The material in this layer breaks when dry, into clods 1 inch or more in diameter, and it is distinctly gray in the exposed cut.
- 70 to 168 inches, dark-gray, when dry, and nearly black, when wet, non-calcareous clay which breaks out, when dry, to fine clods from one-half to 1 inch in diameter. The clods are coated with a thin film of dark-brown or black glistening material. Some soft spots and streaks of crystalline, glistening, dark-colored material in this layer resemble deposits of iron. This layer appears somewhat similar to the layer containing the iron films in the profile described immediately preceding this description.
- 168 to 200 inches+, reddish-yellow noneffervescing clay containing some soft spots of dark material which is probably iron.

This profile was observed in the middle of the spot which is only about 100 feet in diameter, and it describes the different layers at their thickest parts. Nearer the margins of the spot the fifth layer (70 to 168 inches) lies at less depth and is thinner. It is underlain by a layer of reddish-yellow calcareous clay containing spots, films, and threads of calcium carbonate. The material in this layer breaks out as cubelike clods about one-half inch in diameter and having flat faces. Below this reddish-yellow layer is the regular soft caliche layer similar to that under typical Pullman silty clay loam but occurring at a greater depth below the surface. The caliche is underlain by friable reddish-buff calcareous clay containing numerous soft lumps of calcium carbonate. The depth of the caliche and the thickness of the overlying layers increase toward the center of the spot. On each side, the caliche layer dips down as though to pass under the spot, but at a depth of 16 feet below the surface in the middle of the area the caliche is not seen. In some other areas of this included soil, the third layer (24 to 60 inches) is absent, and the gray layer lies within 10 inches of the surface.

The surface relief of all the observed areas of this variation is flat and may represent former depressions, or buffalo wallows, which have been filled in for considerable time, with a consequent abnormal soil development. Below the slight depressions, or buffalo wallows, which are now in existence, the soil is like Randall clay, although it is somewhat darker colored.

An important characteristic of Pullman silty clay loam is the extremely compact and claypanlike character of the material lying at a depth ranging from 5 to 36 inches below the surface. This undoubtedly affects the water-absorbing and water-holding capacities of this soil. All the soil mapped as Pullman in this county has this characteristic.

Amarillo fine sandy loam has the same general layers as Pullman silty clay loam in the same order of arrangement. The color of the different layers is, however, more red. The granular structure of the material, to a depth of 2 feet, is well developed, and no claypan-

like structure occurs in any of the layers. The material of the upper layers, to a depth ranging from 18 to 24 inches, dries and breaks into well-defined large vertical columns, ranging from 3 to 6 inches in diameter and from 12 to 18 inches in depth, with flat vertical faces and sharp angles between the vertical faces, but they have no horizontal faces. A typical profile of Amarillo fine sandy loam as observed $6\frac{1}{2}$ miles southeast of Canyon is as follows:

- 0 to 6 inches, dark reddish-brown noncalcareous fine sandy loam. The surface soil to a depth of 1 inch is very dark brown, loose, and lighter textured. The material breaks out as vertical columns, with faces from 2 to 6 inches in diameter, which are flat and appear like coarse sandpaper, owing to the many fine somewhat rounded particles about one thirty-second inch in diameter, which appear like worm casts, and the larger, somewhat less rounded particles, or granules, about one-eighth inch in diameter, which are grouped together to form the column surface coating.
- 6 to 24 inches, reddish-brown friable noncalcareous loam. The columns and structure of the overlying layer extend down to the bottom of this layer.
- 24 to 70 inches, brownish-red calcareous friable cloddy fine sandy loam which becomes more yellow and more highly calcareous with depth. The lower part of this layer contains a few soft concretions, threads, and films of white calcareous material.
- 70 to 80 inches, the layer of soft caliche which is porous white calcareous material intermixed with yellow fine sandy loam.
- 80 to 100 inches +, the parent material of highly calcareous reddish-buff fine sandy loam.

Zita clay loam is a soil which occurs under environmental conditions of relief, drainage, and vegetation favorable to the complete development of normal soil characteristics. It is a nonreddish normal granular southern chernozem of the High Plains. The Zita soils are the nonreddish equivalents of the Amarillo soils and are typically developed in heavy textures. They occupy smooth surfaces, similar to those occupied by the Pullman soils. They differ from the Pullman soils primarily in that they are granular and much less compact. The cause of the difference between the Zita and Pullman soils apparently lies in the chemical character of the parent materials. By direct observation only, no difference is distinguishable between the soil-forming material underlying this soil and that underlying typical Pullman silty clay loam. A typical profile of Zita clay loam, as observed 5 miles north of Canyon, in a large area with a smooth surface and a slope not greater than 1 percent, is as follows:

- 0 to 6 inches, very dark brown (when dry) granular noncalcareous clay loam or light clay. The dry material crumbles readily to a mass of somewhat rounded particles about one-eighth inch in diameter. The structural particles are of the same type as those in the surface soil of Pullman silty clay loam, but they are much less firmly bound together, and the material breaks readily into the individual granules. The color is nearly black when the material is wet. In cultivated fields, the soil pulverizes to a mealy tilth which causes it to blow easily.
- 6 to 18 inches, very dark brown calcareous clay loam or clay, containing some small spots (structure particles) of brown calcareous material, causing a speckled or variegated color. The material in this layer is friable when moist, slightly hard when dry, and slightly plastic when wet. It grades downward to a lighter color; that is, the light-colored spots become more abundant and the dark-colored material less abundant. Granules, such as occur in the surface soil, become less abundant with depth, and the lower part of this layer consists of a mass of fine somewhat rounded particles about one thirty-second inch in diameter, which resemble worm casts.

18 to 30 inches, brown calcareous friable clay with the worm-castlike structure particles of the overlying layer becoming less abundant with depth and with fine white calcareous films coating the soil crevices and structure particles.

30 to 40 inches, buff friable calcareous clay containing a large quantity of soft white calcareous lumps about 1 inch in diameter.

40 to 60 inches +, pinkish-buff highly calcareous clay. Apparently this is identical with the parent material underlying Pullman silty clay loam.

The native vegetation on this soil includes a smaller proportion of short grasses (buffalo grass and blue grama) than occurs on the Pullman soils, and there is a considerable admixture of such bunch grasses as little bluestem (*Andropogon scoparius*).

Much of the Zita clay loam in Randall County occurs as sloping areas or areas which have been subject to recent deposition of the parent material. The soil, however, is the same as the typical soil.

Randall clay is the poorly drained soil of the lake beds. It is covered with water occasionally for periods ranging from a few days to several weeks, depending on how the lake holds water and on the frequency of rainfall. Those areas which are covered with water for long periods are nearly bare of vegetation, and the soil is distinctly bluish gray. Where wet for only a short time, the land is covered with a heavy growth of grasses and other small plants. Here the soil is dark gray. A typical profile of Randall clay, as observed in a lake bed 2 miles south of Amarillo, is as follows:

0 to 20 inches, dark-gray noncalcareous extremely plastic sticky compact clay which breaks out as small clods with flat faces. Plant roots follow natural soil cracks almost exclusively. Brown peatlike plant roots or root remains are characteristic. These are probably largely those of the dwarf club-rush (*Eleocharis palustris*).

20 to 72 inches +, bluish-gray calcareous clay containing a very few hard white calcareous concretions. The main mass of soil shows no effervescence with hydrochloric acid to a depth of about 40 inches. In the lower part of this layer, a few streaks and spots of yellowish gray occur, and the material becomes lighter colored and somewhat more yellow.

A few areas of this soil are calcareous throughout. The material cracks deeply on drying and forms typical hog wallows—regular minor inequalities of the surface caused by shrinking and cracking.

Fritch fine sandy loam is characterized by a dark sandy noncalcareous surface soil which grades, at a depth of 18 inches, into extremely heavy and compact dark-brown clay. A typical profile, as observed on a flat one-half mile wide, surrounded by higher ridges of Pullman fine sandy loam, with no present indication of imperfect drainage, 8 miles east of Canyon, is as follows:

0 to 14 inches, dark-brown noncalcareous fine sandy loam, in which the structure is the same as in the surface soil of Amarillo fine sandy loam.

14 to 18 inches, a gradational zone.

18 to 32 inches, dark-brown very compact hard noncalcareous clay which is plastic and sticky when wet and breaks into irregular clods, from one-half to 1 inch in diameter. The clods have slick-appearing surfaces which are darker than the insides.

32 to 52 inches, brown calcareous clay containing nodules of calcareous salts which are crystallized. The material breaks into irregular clods as in the layer above. No white films are present.

52 to 66 inches +, brown calcareous clay containing some reddish-yellow spots and some small soft or hard white calcareous concretions. The reddish-yellow color increases with depth.

This soil may represent areas in which other soils have been covered with a coating of fine sandy loam, or it may represent a distinct type of soil development. It is significant, however, that wherever this soil occurs in either Randall or Potter Counties, it has a layer which is darker than the surface layer of any normal soil in these counties; is heavier and more compact (as determined from samples in the laboratory) than the surface soil of any normal soil; and has a more distinct dark-colored film coating the structure particles than in the surface soil of any normal soil. Undoubtedly, in some places this soil comprises areas of Randall clay which have been covered with wind-blown material.

Table 5 gives the results of mechanical analyses of three soils in Randall County.

TABLE 5.—*Mechanical analyses of 3 soils in Randall County, Tex.*

Soil type and sample no.	Depth	Fine gravel	Coarse sand	Medium sand	Fine sand	Very fine sand	Silt	Clay
Pullman silty clay loam	<i>Inches</i>	<i>Percent</i>	<i>Percent</i>	<i>Percent</i>	<i>Percent</i>	<i>Percent</i>	<i>Percent</i>	<i>Percent</i>
448228	0-6	0.1	0.3	0.5	3.1	18.7	48.0	29.3
448229	6-24	1	3	5	2.8	14.2	37.1	45.1
448230	24-36	2	4	6	2.9	15.7	37.3	42.9
448231	36-50	.3	5	.6	3.7	24.2	33.5	37.2
448232	50-60	.2	.3	.5	3.2	22.1	27.4	46.3
448233	60-144+	1	2	3	2.1	13.6	26.8	57.0
Amarillo fine sandy loam.								
448250	0-6	1	8.9	17.2	23.2	19.2	15.4	16.0
448251	6-24	0	6.0	12.8	21.3	20.9	15.0	23.8
448252	24-60	.2	3.8	8.8	16.6	22.1	20.9	27.5
448253	60-80+	1	1.8	3.4	13.2	29.6	21.8	30.1
Richfield silty clay loam								
448211	0-5	4	.8	2.0	7.1	14.9	38.0	36.9
448212	5-18	0	.3	1.5	5.4	11.2	32.3	49.2
448213	18-30	.0	.7	2.2	7.3	12.5	29.9	47.4
448214	30-42+	2.1	2.4	3.0	8.9	10.6	21.8	51.1

SUMMARY

Randall County comprises an area of 920 square miles on the High Plains in the central part of the Texas Panhandle. Palo Duro Canyon and its tributary valleys constitute deeply cut drainageways bordered by rough lands extending in narrow areas across the east-central part. Within the county, an area of about 760 square miles constitutes the smooth nearly flat High Plains, the remainder being rolling or rough and broken. The elevation of the High Plains part of the county ranges from 3,500 to 3,800 feet above sea level.

The mean annual precipitation is 21 inches, about 75 percent of which falls during the growing season. The average length of the frost-free season is 201 days.

The county was first utilized for ranching about 1875. Farming was first attempted as an enterprise separate from ranching about 1900 but did not become extensive until about 1920. Between 1924 and 1929 the amount of land in cultivation greatly increased, a total of 249,323 acres being devoted to crops in 1929.

Winter wheat is the most important crop and constitutes more than 60 percent of the crop acreage. The average acre yield is between 10 and 15 bushels (18 bushels in 1929), although yields differ widely, according to seasonal moisture supply. Milo, kafir, other grain sorghums, and sorgo are important crops. Alfalfa is

grown to some extent on the bottom lands along Palo Duro and Tierra Blanca Creeks. Palo Duro Canyon and the adjoining broken lands are used for cattle ranching.

Fifteen soil types and four phases of types are identified and mapped in addition to rough broken land.

Pullman silty clay loam, the typical wheatland of the High Plains in this section, comprises approximately two-thirds of the land in the county. It is a productive soil characterized by a brown surface soil overlying heavy chocolate-brown clay which grades below into a somewhat red deep soil layer. This overlies a soft caliche layer at a depth of about $4\frac{1}{2}$ feet. About 65 percent of Pullman silty clay loam is under cultivation.

The soil of the lake beds is mapped as Randall clay. It comprises 8.5 percent of the total area of the High Plains in Randall County.

A total of 501,000 acres of soil is well suited to the production of farm crops.

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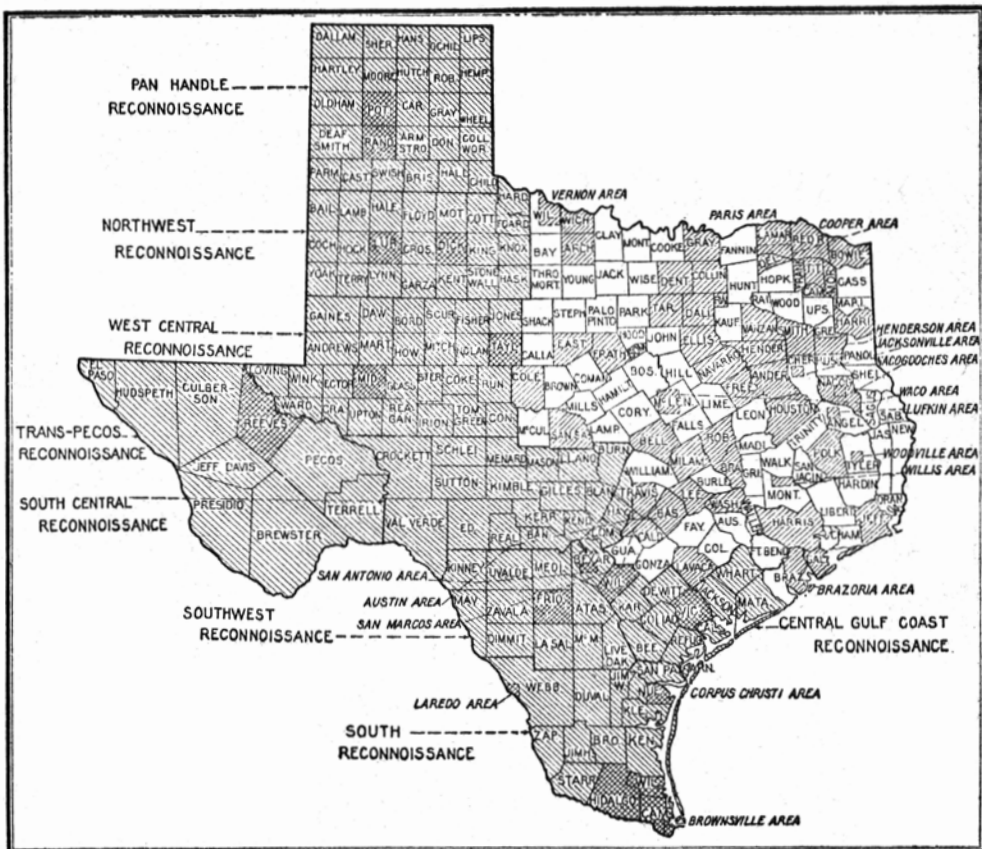
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Areas surveyed in Texas, shown by shading. Detailed surveys shown by northeast-southwest hatching; reconnaissance surveys shown by northwest-southeast hatching; crosshatching indicates areas covered in both ways.

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